DISCRETE *P*-WAVE VELOCITY -- PWS

Introduction

P-wave or sonic velocity measurements are a measure of the velocity of seismic waves through earth materials, distance versus time. *P*-wave velocity varies with the lithology, porosity, and bulk density of the material; state of stress, such as lithostatic pressure; and fabric or degree of fracturing. In marine sediments and rocks, velocity values are also controlled by the degree of consolidation and lithification, fracturing, occurrence and abundance of free gas and gas hydrate. Together with density measurements, sonic velocity is used to calculate acoustic impedance, or reflection coefficients, which can be used to estimate the depth of reflectors observed in seismic profiles and to construct synthetic seismic profiles.

P-wave velocity data had been collected during the Deep Sea Drilling Project (DSDP). The Hamilton-Frame system was first used during DSDP Leg 15 and was part of the equipment that was transferred to the Ocean Drilling Program (ODP). Discrete velocity measurements were made on split sections or samples. After the *P*-wave logger (PWL) was installed to collect higher density velocity data, the discrete measurements were useful for studying the anisotropy of the cored material and to fill in when the PWL was no longer able to make good measurements.

PWS Data Acquisition

ODP modified and updated the electronics for the Hamilton-Frame system, but the general data collection procedures were the same as described by Boyce, 1973. Discrete samples had to be prepared carefully in order to ensure good contact with the transducers. Sometimes split sections would be measured in liners when the sediments were too weak to be handled without being destroyed. Measurements could be made in three directions: **A** or **Z** -- parallel to the core axis; **B** or **Y** -- perpendicular to core axis and parallel to split surface; and **C** or **X** -- perpendicular to core axis and perpendicular to split surface. (Direction designation differed between legs).

On Leg 130, the Digital Sound Velocimeter (DSV) system, developed by Dalhousie University and Bedford Institute of Oceanography, was brought aboard the *JR* to demonstrate the system and to collect velocity data on unconsolidated sediments. This system was computer-controlled and collected not only the raw data but the full waveform that could be analyzed later. ODP installed a DSV system on Leg 138. Two transducer pairs were designed to be inserted into soft and semi-consolidated sediments. They were mounted orthogonal to each other to measure along the core axis (Z) and perpendicular to the axis and within the split plane (Y).

Both the Hamilton-Frame system and the DSV were replaced by new systems during Leg 169. Hardware and software had improved significantly and the new systems were designed to take advantage of those advancements. PWS1 and PWS2 Insertion Probe system on a split-core track replaced the DSV. The Hamilton-Frame was replaced by the PWS3 Contact Probe system which maintained the capability of measuring discrete samples or split core. A major upgrade to the PWS3 system occurred during Leg 191 when new data acquisition hardware was installed. This required modifications of both the data acquisition software and the Janus PWS3 tables. The changes to the PWS3 system were modeled after the PWL system.

Table 1. Discrete *P*-wave Velocity systems

Legs	Equipment	Comments
101 – 138	Hamilton-Frame velocimeter – variable frequency (400 - 500 kHz) compressional wave transducers, pulse generator and amplifier, oscilloscopes.	Unknown how data were recorded. Data may have been recorded on log sheets and entered later into S1032 database.
130	Dalhousie/Bedford Institute DSV	Third-party equipment brought onboard for demonstration.
138 – 168	ODP DSV operational Data acquisition program for the Hamilton-Frame	ODP DSV installed on Leg 138. New data acquisition program initiated for Hamilton-Frame. Various data acquisition software changes and data format changes for both Hamilton-Frame and DSV.
169 – 191	PWS1, PWS2, PWS3	Hardware and software upgrade. Leg 171 Janus database operational. Minor software changes.
191	PWS3	Major hardware and software upgrade. Change in signal interface resulted in a major change in data format.
192 – 210	PWS1, PWS2, PWS3	Minor software changes during this time

Standard Operating Procedures

The basic velocity calculation is: $\boldsymbol{v = d / t}$. For laboratory measurements, the liner and the characteristics of the electronics can be sources of error in the measured velocity of the cored material. There are three types of time delays that can be subtracted to correct the travel time. Those are 1) t_{delay} – a delay related to the transducers and electronics; 2) t_{pulse} – a delay related to the peak detection procedure; and 3) t_{liner} – the transit time through the core liner. For routine measurements on discrete samples, the calculation for the velocity is:

$$\boldsymbol{v_{core} = [(d'_{core}\ \{- d_{liner}\}) / (t_0 - t_{pulse} - t_{delay} - \{t_{liner}\})] \times 1000,}$$

where

v_{core} = corrected velocity through core (km/s),
d'_{core} = measured distance between transducers (mm),
d_{liner} = liner wall thickness (mm) {when necessary}, and
t_0 = measured total travel time (μs).

Hamilton-Frame Velocimeter. Explanatory Notes in the Initial Report volumes referred back to Boyce, (1973) where the operating procedures for the Hamilton-Frame system were described. It was important to prepare the sample correctly in order to get good contact between the transducers and the core material or core liner if measuring a split core. The time delay was determined by measuring the time with the transducers in contact with each other, zero distance. Initially, the measurements were likely logged by hand, and later entered into the S1032 database. The handwritten logsheets were returned to ODP/TAMU for archival. A computer data acquisition program was implemented on Leg 138, but there is little documentation about this or subsequent programs. Calibrations of the Hamilton-Frame system were not documented.

Digital Sound Velocimeter. The DSV had two sets of piezoelectric transducers that were inserted into unconsolidated and semi-soft material. One set was separated by approximately 7 cm along the core axis (Z); the other set was separated by approximately 3.5 cm perpendicular to the core axis and parallel to the split surface. All functions of this system were controlled by a dedicated computer, including creating files with velocity measurements. Thermistors monitored the temperature of the core material during measurement. Periodically, the separation was checked by running a calibration procedure in distilled water. Time delays were estimated using a series of aluminum and lucite standards.

PWS1 and PWS2 Insertion Probe Systems. The principal behind PWS1 and PWS2 was the same as the DSV. In addition to the improvement in hardware and computer control of all data acquisition, calibration procedures were implemented, and all measurement and calibration data were uploaded to the Janus database. The distance between the transducers was measured with calipers at least once per leg, more often when being heavily used. The distance values were considered constant. The t_{delay} calibration was done by inserting the probes into a container filled with distilled water of known temperature and therefore of known velocity, and calculating the time delay as the difference between the measured transit time and the known transit time in water. Control measurements as described in the data model were not implemented during ODP.

PWS3 Contact Probe System. The PWS3 system was an upgraded Hamilton-Frame system. Improvements in hardware and computer control allowed the measurement and calibration procedures to be simplified. Rapid, precise measurement of sample thickness, and pressure control on the transducers helped to ensure that the transducers contacted the split core or sample properly. Calibration of the PWS3 system was equivalent to the procedure for the PWL. Standards of different thickness were measured to obtain total transit times. Least-squares regression was run to determine the time delay. All data were stored in the Janus database. Control measurements as described in the data model were not implemented during ODP.

Archive

Pre-Janus Archive

From the beginning of ODP, it appears that the velocity data collected on the Hamilton-Frame were logged by hand on logsheets. Those data were later entered into the S1032 database. The completeness of the early archive is dependent upon what was written on the logsheets or transcribed from scientists' notes. A new data acquisition code was implemented for the Hamilton-Frame at the same time the new DSV system was installed. Both of those systems created data files that were archived on the ODP/TAMU servers.

Migration of discrete velocity data to Janus

The data models for the discrete velocity data can be found in Appendix I. Included are the relational diagram and the list of the tables that contain data pertinent to PWS, the column names, and the definition of each column attribute. ODP Information Services Database Group was responsible for the migration of pre-Leg 171 data to Janus. The data collected on the Hamilton-Frame system were migrated to the PWS3 tables. Data collected on the DSV system were migrated to PWS1 or PWS2, with all data collected in the Z (or A) direction (parallel to core axis) migrated to the PWS1 tables, and data collected in the Y (or B) direction (perpendicular to core axis, parallel to split surface) migrated to the PWS2 tables.

More detailed information about ODP *P*-wave velocity measurements can be found in *Technical Note 26: Physical Properties Handbook,* Chapter 6.

Janus PWS Data Format

PWS *P*-wave data can be retrieved from Janus Web using a predefined query. The *P*-wave Velocity (PWS Split-Core System) query webpage allows the user to extract data using the following variables to restrict the amount of data retrieved: leg, site, hole, core, section, specific run numbers, velocity type, depth range, or latitude and longitude ranges. In addition, the user can use the Output Raw Data option in the query to extract the raw measurements and calibration parameters used to calculate the velocity values.

Table 2A lists the data fields retrieved from the Janus database for the PWS1 and PWS2 predefined query with Output Raw Data option turned on. The structure of the tables for PWS1 and PWS2 are identical, so the table names are interchangeable. Table 2B lists the data fields retrieved from the PWS3 tables. The first column contains the data item; the second column indicates the Janus table or tables in which the data were stored; the third column is the Janus column name or the calculation used to produce the value. Appendix II contains additional information about the fields retrieved using the Janus Web PWS query, and the data format for the archived ASCII files.

Table 2A. PWS1 and PWS2 *P*-Wave Velocity query with Output Raw Data option

Item Name	Janus Table	Janus Column Name and Calculation
Leg	SECTION	Leg
Site	SECTION	Site
Hole	SECTION	Hole
Core	SECTION	Core
Type	SECTION	Core_type
Section	SECTION	Section_number
Top (cm)	PWS1_SECTION_DATA	PP_Top_Interval x 100
Bottom (cm)	PWS1_SECTION_DATA	PP_Bottom_Interval x 100
Depth (mbsf)	DEPTH_MAP, PWS1_SECTION_DATA	DEPTH_MAP.Map_Interval_Top + PWS1_SECTION_DATA.PP_Top_Interval
Direction	PWS1_SECTION	Direction
Velocity (m/s)	PWS1_SECTION_DATA	PWS1_Velocity
Run Number	PWS1_SECTION	Run_Num
Run Date/Time	PWS1_SECTION	Run_Date_Time (yyyy-mm-dd hh:mm)
Core Temp	PWS1_SECTION	Core_Temperature
Raw Data	PWS1_SECTION	Raw_data_collected
Measurement No.	PWS1_SECTION_DATA	Measurement_No
Separation (mm)	PWS1_SECTION_DATA	Transducer_separation
Time Mean (μs)	PWS1_SECTION_DATA	Measured_Time
Calib Date/Time	PWS1_CALIBRATION	Calibration_Date_Time (yyyy-mm-dd hh:mm)
Calib. Delay	PWS1_CALIBRATION	Delay

Table 2B. PWS3 *P*-Wave Velocity query with Output Raw Data option

Item Name	Janus Table	Janus Column Name and Calculation
Leg	SECTION	Leg
Site	SECTION	Site
Hole	SECTION	Hole
Core	SECTION	Core
Type	SECTION	Core_type
Section	SECTION	Section_number
Top (cm)	PWS3_SECTION_DATA	PP_Top_Interval x 100
Bottom (cm)	PWS3_SECTION_DATA	PP_Bottom_Interval x 100
Depth (mbsf)	DEPTH_MAP, PWS3_SECTION_DATA	DEPTH_MAP.Map_Interval_Top + PWS_SECTION_DATA.PP_Top_Interval
Direction	PWS3_SECTION	Direction
Velocity (m/s)	PWS3_SECTION_DATA	PWS3_Velocity
Run Number	PWS3_SECTION	Run_Num
Run Date/Time	PWS3_SECTION	Run_Date_Time (yyyy-mm-dd hh:mm)
Core Temp (C)	PWS3_SECTION_DATA	Core_temperature
Raw Data	PWS3_SECTION	Raw_data_collected
Measurement No.	PWS3_SECTION_DATA	Measurement_no
Separation Mean (mm)	PWS3_SECTION_DATA	Meas_separation_mean
Time Mean (μs)	PWS3_SECTION_DATA	Meas_time_mean
Calib Date/Time	PWS3_CALIBRATION	Calibration_Date_Time (yyyy-mm-dd hh:mm)
Liner Correction	PWS3_SECTION	Liner_Correction
Standard	PHYSICAL_PROPERTIES_STANDARD	Standard_name
Standard Set	PHYSICAL_PROPERTIES_STANDARD	Standard_set_name
Standard Expected	PHYSICAL_PROPERTIES_STD_DATA	Property_value
Contact Pressure (kPa)	PWS3_SECTION_DATA	Contact_pressure
Liner thickness (mm)	PWS3_SECTION_DATA	Liner_thickness
Calib. Delay M0	PWS3_CALIBRATION	Delay_m0
Calib. Delay 1/M1	PWS3_CALIBRATION	Delay_1_over_m1
Calib. Delay Mean Square Error	PWS3_CALIBRATION	Delay_mse
Calib. Separation M0	PWS3_CALIBRATION	Separation_m0
Calib. Separation M1	PWS3_CALIBRATION	Separation_m1
Calib. Separation Mean Square Error	PWS3_CALIBRATION	Separation_mse

Data Quality

There are several things that can affect the quality of PWS discrete velocity data. Type of material and the drilling method used to recover the core are major factors. There must be good acoustic coupling between the core material and the transducers. When taking a measurement through the core liner, there must be good coupling not only between the transducer and the core liner, but also between the core material and the core liner. Even in soft sediment, less cohesion of the sediments, microcracks or gas voids can make good measurements impossible. PWS measurements were often used to augment the velocity data from the PWL system when the quality of core material prevented reliable measurements. Table 3 summarizes discrete velocity measurements taken on ODP cores.

Table 3: PWS Analysis Statistics

	PWS 1	PWS 2	PWS 3
APC – coretype H	9,618	8,659	26,140
XCB – coretype X	1,819	1,138	21,590
RCB – coretype R	306	107	53,818
TOTAL	11,743	9,904	102,136

One commonly occurring problem was error in the measurement location. This problem became more apparent after computer-controlled data acquisition programs were implemented. If the equipment was not properly zeroed before taking the measurement, the measurement location would not be recorded properly. Notation of the measurement interval on the logsheets could be used to correct the location error, but logsheets were not available for all legs, or locations were not always documented.

One other source of error was operator error. Anything written or typed was a potential source of error. Measurements were taken manually on the Hamilton-Frame with the results written on logsheets. These data were then typed into S1032. Incomplete data on the log sheets prevent any verification of the older data. Typographical errors when transcribing the data into S1032 occasionally happened. Even when data acquisition programs were implemented to collect the velocity data, the operator manually entered the core information. Some mistakes were not identified. Often, the scientific party found errors and corrected the data included in the Initial Report volume, but the data sent back to ODP/TAMU did not get corrected.

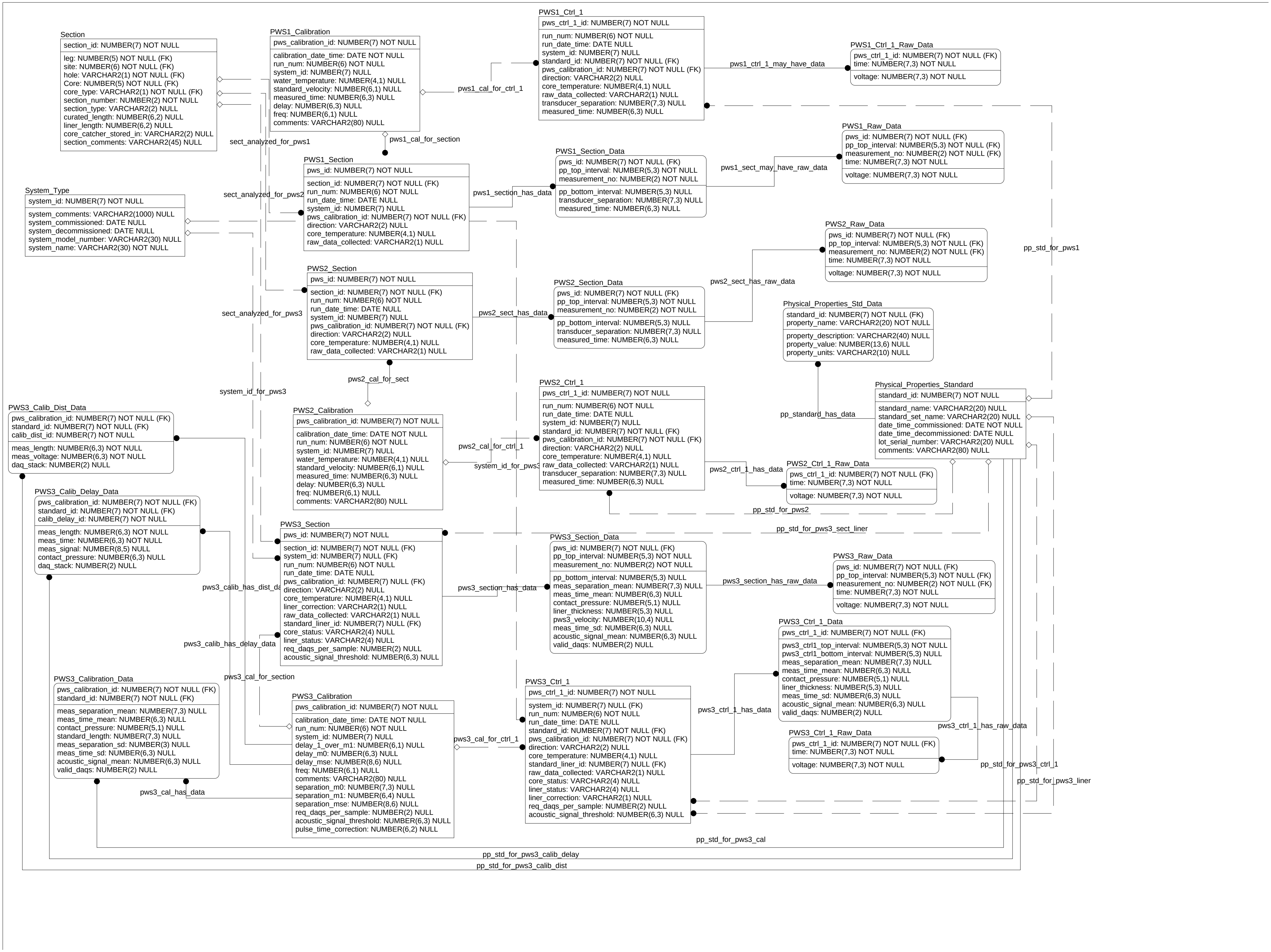
The verification of the entire PWS data set was not completed due to time constraints. Most data collected after the Janus database was operational on Leg 171 were verified as part of the Janus data management and verification procedures (see Metadata Introduction). Some verification was done on the pre-Leg 171 data; however, if there is a discrepancy between the database and data in the Initial Report volumes, the published data should be considered more reliable.

References

Blum, P., 1997, Physical Properties Handbook: A guide to the shipboard measurement of physical properties of deep-sea cores, ODP Tech. Note 26.

Boyce, R.E., 1973, Appendix I. Physical Properties - Methods. *In* Edgar, N.T., Saunders, J.B., et al., Initial Reports of the Deep Sea Drilling Project, Volume 15: Washington (U.S. Government Printing Office), p. 1115-1128.

Boyce, R.E., 1976, Appendix I. Definitions and Laboratory Techniques of Compressional Sound Velocity Parameters and Wet-Water Content, Wet-Bulk Density, and Porosity Parameters by Gravimetric and Gamma Ray Attenuation Techniques. *In* Schlanger, S.O., Jackson, E.D., et al., Initial Reports of the Deep Sea Drilling Project, Volume 33, p. 931-951.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liner_length: NUMBER(6,2) NULL
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freq: NUMBER(6,1) NULL
comments: VARCHAR2(80) NULL
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measurement_no: NUMBER(2) NOT NULL
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transducer_separation: NUMBER(7,3) NULL
measured_time: NUMBER(6,3) NULL
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raw_data_collected: VARCHAR2(1) NULL
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system_name: VARCHAR2(30) NOT NULL
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voltage: NUMBER(7,3) NOT NULL
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transducer_separation: NUMBER(7,3) NULL
measured_time: NUMBER(6,3) NULL
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raw_data_collected: VARCHAR2(1) NULL
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contact_pressure: NUMBER(6,3) NULL
daq_stack: NUMBER(2) NULL
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pws3_cal_has_data
pp_std_for_pws3_cal
pp_std_for_pws3_calib_delay
pp_std_for_pws3_calib_dist

APPENDIX I: Janus Data Model – PWS

Discrete *P*-Wave Velocity – PWS		
Table Name	**Column Name**	**Column Comment**
PWS1_Section	pws_id	Unique Oracle-generated sequence number for each PWS1 analysis run.
	section_id	Unique Oracle-generated sequence number to identify each section.
	run_num	Number identifying a run generated by the data acquisition software. This number is not used to identify the run in Janus because it may not be unique.
	run_date_time	Timestamp when analysis was run.
	system_id	Unique identifier for a system of equipment used to collect data.
	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	direction	Direction of measurement relative to a section of core. Z is along the core axis.
	core_temperature	Temperature of the core in °C.
	raw_data_collected	Raw data flag to indicate whether raw data for a measurement was saved. Valid values - Y or N.

PWS1_Section_Data	pws_id	Unique Oracle-generated sequence number for each PWS1 analysis run.
	pp_top_interval	The top interval of a measurement in meters measured from the top of a section.
	measurement_no	The number of the measurement. Used to differentiate multiple measurements taken at the same interval.
	pp_bottom_interval	The bottom interval of a measurement in meters measured from the top of a section.
	transducer_separation	Distance between a pair of transducers, in millimeters.
	measured_time	Time measured for a wave to travel between the transducers, in microseconds.

PWS1_Raw_Data	pws_id	Unique Oracle-generated sequence number for each PWS1 analysis run.
	pp_top_interval	The top interval of a measurement in meters measured from the top of a section.
	measurement_no	The number of the measurement taken, used to differentiate multiple measurements taken at the same interval.
	time	Time associated with a velocity measurement, in microseconds.
	voltage	Measured voltage, in millivolts.

PWS1_Calibration	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	calibration_date_time	Timestamp when calibration was done - supplied by instrument.
	run_num	Run number associated with a data analysis run.
	system_id	Unique identifier for a system of equipment used to collect data.
	water_temperature	Temperature of water being measured as a standard, in °C.
	standard_velocity	The measured velocity of a standard.
	measured_time	Time measured for a wave to travel between the transducers, in microseconds.
	delay	The delay used while taking a measurement, in microseconds.
	freq	Frequency associated with taking a measurement, in kHz.
	comments	General comments

PWS1_Ctrl_1	pws_ctrl_1_id	Unique Oracle-generated sequence number for each PWS1 control_1 analysis.
	run_num	Run number associated with a data analysis run.
	run_date_time	Timestamp when analysis was run.
	system_id	Unique identifier for a system of equipment used to collect data.
	standard_id	Identifier for a physical properties standard.
	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	direction	Direction of measurement relative to a section of core. Z is along the core axis.
	core_temperature	Temperature of the core in °C.
	raw_data_collected	Raw data flag to indicate whether raw data for a measurement was saved. Valid values - Y or N.

Discrete *P*-Wave Velocity – PWS		
Table Name	**Column Name**	**Column Comment**
	transducer_separation	Distance between a pair of transducers, in mm.
	measured_time	Time measured for a wave to travel between the transducers, in microseconds.

PWS1_Ctrl_1_Raw_Data	pws_ctrl_1_id	Unique Oracle-generated sequence number for each PWS1 control_1 analysis.
	time	The time associated with a velocity measurement, in microseconds.
	voltage	Measured voltage, in millivolts.

PWS2_Section	pws_id	Unique Oracle-generated sequence number for each PWS2 analysis run.
	section_id	Unique number generated by system to identify section.
	run_num	Run number associated with a data analysis run.
	run_date_time	Timestamp when analysis was run.
	system_id	Unique identifier for a system of equipment used to collect data.
	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	direction	Direction of measurement relative to a section of core. Y is perpendicular to the core axis and parallel to the split core surface.
	core_temperature	Temperature of the core in ^{o}C.
	raw_data_collected	Raw data flag to indicate whether raw data for a measurement was saved. Valid values - Y or N.

PWS2_Section_Data	pws_id	Unique Oracle-generated sequence number for each PWS2 analysis run.
	pp_top_interval	The top interval of a measurement in meters measured from the top of a section.
	measurement_no	The number of the measurement taken, used to differentiate multiple measurements taken at the same interval.
	pp_bottom_interval	The bottom interval of a measurement in meters measured from the top of a section.
	transducer_separation	Distance between a pair of transducers, in millimeters.
	measured_time	Time measured for a wave to travel between the transducers, in microseconds.

PWS2_Raw_Data	pws_id	Unique Oracle-generated sequence number for each PWS2 analysis run.
	pp_top_interval	The top interval of a measurement in meters measured from the top of a section.
	measurement_no	The number of the measurement taken, used to differentiate multiple measurements taken at the same interval.
	time	The time associated with a velocity measurement, in microseconds.
	voltage	Measured voltage, in millivolts.

PWS2_Calibration	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	calibration_date_time	Time stamp identifying when calibration was done - supplied by instrument data files.
	run_num	Run number associated with a data analysis run.
	system_id	Unique identifier for a system of equipment used to collect data.
	water_temperature	The temperature of water being measured as a standard, in ^{o}C.
	standard_velocity	The measured velocity of a standard.
	measured_time	Time measured for a wave to travel between the transducers, in microseconds.
	delay	The delay used while taking a measurement, in microseconds.
	freq	Frequency associated with taking a measurement, in kHz.
	comments	General comments

PWS2_Ctrl_1	pws_ctrl_1_id	Unique Oracle-generated sequence number for each PWS2 control_1 analysis.
	run_num	Run number associated with a data analysis run.
	run_date_time	Timestamp when analysis was run.

Discrete *P*-Wave Velocity – PWS

Table Name	Column Name	Column Comment
	system_id	Unique identifier for a system of equipment used to collect data.
	standard_id	Identifier for a physical properties standard.
	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	direction	Direction of measurement relative to a section of core. Y is perpendicular to the core axis and parallel to the split core surface.
	core_temperature	Temperature of the core in ^oC.
	raw_data_collected	Raw data flag to indicate whether raw data for a measurement was saved. Valid values - Y or N.
	transducer_separation	Distance between a pair of transducers, in mm.
	measured_time	Time measured for a wave to travel between the transducers, in microseconds.

Table Name	Column Name	Column Comment
PWS2_Ctrl_1_Raw_ Data	pws_ctrl_1_id	Unique Oracle-generated sequence number for each PWS2 control_1 analysis.
	time	The time associated with a velocity measurement, in microseconds.
	voltage	Measured voltage, in millivolts.

Table Name	Column Name	Column Comment
PWS3_Section	pws_id	Unique Oracle-generated sequence number for each PWS3 analysis run.
	section_id	Unique number generated by system to identify section.
	system_id	Unique identifier for a system of equipment used to collect data.
	run_num	Run number associated with a data analysis run.
	run_date_time	Timestamp when analysis was run.
	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	Direction	Direction of measurement relative to a section of core. Valid values: X - perpendicular to core axis and perpendicular to split surface, Y - perpendicular to core axis and parallel to split surface, Z - parallel to core axis.
	core_temperature	Temperature of the core in ^oC.
	liner_correction	Y or N if liner correction used.
	raw_data_collected	Raw data flag to indicate whether raw data for a measurement was saved. Valid values - Y or N.
	standard_liner_id	Identifier for a physical properties standard.
	core_status	Added Dec. 2000. Indicates whether the measured section has been split. Valid values: FULL –whole core, HALF – split core.
	liner_status	Records if a core liner was present, a split liner or no liner. Valid values are FULL, HALF and NONE.
	req_daqs_per_sample	Requested number of data acquisitions taken per sample interval.
	acoustic_signal_threshold	The strength of the acoustic signal for a velocity measurement used. Valid values 0 -255. This was changed from N(3) to N(4,3) by Bill Mills in Dec. 2000 because of PWS hardware upgrade.

Table Name	Column Name	Column Comment
PWS3_Section_Data	pws_id	Unique Oracle-generated sequence number for each PWS3 analysis run.
	pp_top_interval	The top interval of a measurement in meters measured from the top of a section.
	measurement_no	The number of the measurement taken, used to differentiate multiple measurements taken at the same interval.
	pp_bottom_interval	The bottom interval of a measurement in meters measured from the top of a section.
	meas_separation_mean	Distance between a pair of transducers, in mm. Name changed from transducer_separation to meas_separation_mean, Dec. 2000.
	meas_time_mean	Time measured for a wave to travel between the transducers, in microseconds. Name changed from measured_time to meas_time_mean, Dec. 2000.
	contact_pressure	Contact pressure used during a measurement, in kPa.
	liner_thickness	Liner thickness in mm.
	pws3_velocity	Added Oct. 2000 to be able to enter velocity results in cases where calibration info was not available.
	meas_time_sd	The standard deviation of the measured time for a signal to travel between a pair of transducers, in microseconds. Added Dec. 2000.

Discrete *P*-Wave Velocity – PWS		
Table Name	**Column Name**	**Column Comment**
	acoustic_signal_mean	The mean value of the acoustic signal from a velocity measurement. Added Dec. 2000.
	valid_daqs	Number of valid data acquisitions from those attempted.

PWS3_Raw_Data	pws_id	Unique Oracle-generated sequence number for each PWS3 analysis run.
	pp_top_interval	The top interval of a measurement in meters measured from the top of a section.
	measurement_no	The number of the measurement taken, used to differentiate multiple measurements taken at the same interval.
	time	The time associated with a velocity measurement, in microseconds.
	voltage	Measured voltage, in millivolts.

PWS3_Calibration	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	calibration_date_time	Time stamp identifying when calibration was done - supplied by instrument data files.
	run_num	Run number associated with a data analysis run.
	system_id	Unique identifier for a system of equipment used to collect data.
	delay_1_over_m1	Calculated time calibration slope, in microseconds/millimeter. Changed name from delay_1_m1 to delay_1_over_m1, Dec. 2000.
	delay_m0	Calculated time calibration constant, in microseconds.
	delay_mse	Mean squared error
	freq	Frequency associated with taking a measurement, in kHz.
	comments	General comments
	separation_m0	Calculated distance calibration constant in mm. Added Dec. 2000.
	separation_m1	Calculated distance calibration slope, in mm/volts. Added Dec. 2000.
	separation_mse	Mean square error in distance calibration constant calculation. Added Dec. 2000.
	req_daqs_per_sample	The requested number of data acquisitions to be taken per sample interval. Added Dec. 2000.
	acoustic_signal_threshold	The strength of the acoustic signal for a velocity measurement.
	pulse_time_correction	Time correction in reference to peak detection.

PWS3_Calibration_ Data	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.t
	standard_id	Identifier for a physical properties standard.
	meas_separation_mean	Distance between a pair of transducers, in mm. Name changed from transducer_separation to meas_separation_mean, Dec. 2000.
	meas_time_mean	Time measured for a wave to travel between the transducers, in microseconds. Name changed from measured_time to meas_time_mean, Dec. 2000.
	contact_pressure	The contact pressure used during a measurement, in kPa.
	standard_length	Length of standard in millimeters. Added Dec. 2000.
	meas_separation_sd	Standard deviation of the measurement of length of standard.
	meas_time_sd	The standard deviation of the measured time for a signal to travel between a pair of transducers, in seconds.
	acoustic_signal_mean	The mean value of the acoustic signal from a velocity measurement.
	valid_daqs	Number of valid data acquisitions from those attempted.

PWS3_Calib_Delay_ Data	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument.
	standard_id	Identifier for a physical properties standard.
	calib_delay_id	Unique Oracle-generated sequence number for each delay calibration recorded for the PWS instrument.
	meas_length	Length of standard in millimeters.
	meas_time	Measured time in microseconds.
	meas_signal	Signal level in volts.
	contact_pressure	The contact pressure used during a measurement, in kPa.
	daq_stack	Number of valid data acquisitions.

Discrete *P*-Wave Velocity – PWS		
Table Name	**Column Name**	**Column Comment**
PWS3_Calib_Dist_ Data	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument
	standard_id	Identifier for a physical properties standard.
	calib_dist_id	Unique Oracle-generated sequence number for each distance calibration recorded for the PWS instrument.
	meas_length	Length of standard in millimeters.
	meas_voltage	Signal level in volts.
	daq_stack	Number of valid data acquisitions.

PWS3_Ctrl_1	pws_ctrl_1_id	Unique Oracle-generated sequence number for each PWS3 control_1 analysis.
	system_id	Unique identifier for a system of equipment used to collect data.
	run_num	Run number associated with a data analysis run.
	run_date_time	Timestamp when analysis was run.
	standard_id	Identifier for a physical properties standard.
	pws_calibration_id	Unique Oracle-generated sequence number for each velocity calibration recorded for the PWS instrument
	direction	Direction of measurement relative to a section of core. Valid values: X - perpendicular to core axis and perpendicular to split surface, Y - perpendicular to core axis and parallel to split surface, Z - parallel to core axis.
	core_temperature	Temperature of the core in ^{o}C.
	standard_liner_id	Identifier for a physical properties standard.
	raw_data_collected	Raw data flag to indicate whether raw data for a measurement was saved. Valid values - Y or N.
	core_status	Added Dec. 2000
	liner_status	Records if a core liner was present, a split liner or no liner. Valid values are FULL, HALF and NONE.
	liner_correction	Y or N if liner correction used.
	req_daqs_per_sample	Requested number of data acquisitions taken per sample interval.
	acoustic_signal_threshold	The strength of the acoustic signal for a velocity measurement.

PWS3_Ctrl_1_Data	pws_ctrl_1_id	Unique Oracle-generated sequence number for each PWS control_1 analysis.
	pws3_ctrl1_top_interval	The top interval of a measurement in meters measured from the top of a section.
	pws3_ctrl1_bottom_interv al	The bottom interval of a measurement in meters measured from the top of a section.
	meas_separation_mean	Distance between a pair of transducers, in mm. Name changed from transducer_separation to meas_separation_mean, Dec. 2000.
	meas_time_mean	Time measured for a wave to travel between the transducers, in microseconds. Name changed from measured_time to meas_time_mean, Dec. 2000.
	contact_pressure	The contact pressure used during a measurement, in kPa.
	liner_thickness	Liner thickness in mm.
	meas_time_sd	The standard deviation of the measured time for a signal to travel between a pair of transducers, in seconds.
	acoustic_signal_mean	The mean value of the acoustic signal from a velocity measurement.
	valid_daqs	Number of valid data acquisitions from those attempted.

PWS3_Ctrl_1_Raw_ Data	pws_ctrl_1_id	Unique Oracle-generated sequence number for each PWS3 control_1 analysis.
	time	The time associated with a velocity measurement, in microseconds.
	voltage	Measured voltage, in millivolts.

Discrete *P*-Wave Velocity – PWS		
Table Name	**Column Name**	**Column Comment**
Physical_Properties_ Standard	standard_id	Identifier for a physical properties standard.
	standard_name	Name of a physical properties standard.
	standard_set_name	The name for a set of physical properties standards.
	date_time_commissioned	The date that a physical properties standard went into use.
	date_time_decommissioned	The date that a physical properties standard discontinues being used.
	lot_serial_number	Information concerning the lot and/or serial number associated with a physical properties standard.
	comments	General comments

Physical_Properties_ Std_Data	standard_id	Identifier for a physical properties standard.
	property_name	A property associated with a physical properties standard, for example 'material' or 'density'.
	property_description	A description of a property associated with a physical properties sample.
	property_value	The value of a property associated with a physical properties standard.
	property_units	The units associated with a property for a physical properties sample.

Section	section_id	Unique Oracle-generated sequence number to identify each section. This is done because of the physical subsection / zero section problems. In adding new sections, deleting sections or changing sections - don't want to have to renumber.
	leg	Number identifying the cruise for which data were entered into the database.
	site	Number identifying the site from which the core was retrieved. A site is the position of a beacon around which holes are drilled.
	hole	Letter identifying the hole at a site from which a core was retrieved or data were collected.
	Core	Sequential numbers identifying the cores retrieved from a particular hole. Cores are generally 9.5 meters in length, and are numbered serially from the top of the hole downward.
	core_type	A letter code identifying the drill bit/coring method used to retrieve the core.
	section_number	Cores are cut into 1.5 m sections. Sections are numbered serially, with Section 1 at the top of the core.
	section_type	Used to differentiate sections of core (S) from core catchers (C). Previously, core catchers were stored as section CC, but in Janus core catchers are given the next sequential number from the last section recovered.
	curated_length	The length of the section core material, in meters. This may be different than the liner length for the same section. Hard rock cores will often have spacers added to prevent rock pieces from damaging each other.
	liner_length	The original length of core material in the section, in meters. Sum of liner lengths of all the sections of a core equals core recovery.
	core_catcher_stored_in	Sometimes the core catcher is stored in a D tube with a section. core_catcher_stored_in contains the section number of the D tube that holds the core catcher.
	section_comments	Comments about this section.

System_Type	system_id	Unique identifier for a system of equipment used to collect data.
	system_comments	Comments associated with a piece of analytical equipment.
	system_commissioned	Date that a piece of equipment started to be used to collect scientific data for the ODP.
	system_decommissioned	Date that a piece of analytical equipment was no longer used by ODP to analyzed samples for scientific data.
	system_model_number	The model number of a piece of equipment used for scientific analysis.
	system_name	The name for a piece of equipment used for analysis.

Appendix IIA: Description of data items from PWS1 and PWS2 queries.

Column Name	Column Description and Calculation	Format
Leg	Number identifying the cruise. The ODP started numbering the scientific cruises of the *JR* at Leg 101. A leg was nominally two months duration. During the 18+ years of the ODP, there were 110 cruises on the *JR*.	Integer 3
Site	Number identifying the site. A site is the location where one or more holes were drilled while the ship was positioned over a single acoustic beacon. The *JR* visited 656 unique sites during the course of the ODP. Some sites were visited multiple times, including some sites originally visited during the Deep Sea Drilling Program for a total of 673 site visits.	Integer 4
Hole	Letter identifying the hole. Multiple holes could be drilled at a single site by pulling the drill pipe above the seafloor, moving the ship some distance away and drilling another hole. The first hole was designated 'A' and additional holes proceeded alphabetically at a given site. Location information for the cruise was determined by hole latitude and longitude. During ODP, there were 1818 holes drilled or deepened.	Text 1
Core	Cores are numbered serially from the top of the hole downward. Cored intervals are up to 9.7 m long, the maximum length of the core barrel. Recovered material was placed at the top of the cored interval, even when recovery was less than 100%. More than 220 km of core were recovered by the ODP.	Integer 3
Type	All cores are tagged by a letter code that identifies the coring method used.	Text 1
Section	Cores are cut into 1.5 m sections in order to make them easier to handle. Sections are numbered serially, with Section 1 at the top of the core. PWL measurements were made on sections. Core Catcher sections identified as "CC".	Integer 2 (Text 2)
Top (cm)	The top interval of a measurement in centimeters measured from the top of a section.	Decimal F5.1
Bottom (cm)	The bottom interval of a measurement in centimeters measured from the top of a section.	Decimal F5.1
Depth (mbsf)	Distance in meters from the seafloor to the sample location.	Decimal F7.3
Direction	Direction of measurement relative to a section of core. X - perpendicular to core axis and perpendicular to split surface, Y - perpendicular to core axis and parallel to split surface, Z - parallel to core axis.	Text 2
Velocity (m/s)	Calculated compressional velocity in meters per second.	Decimal F10.4
Run Number	Number generated by the data acquisition software, to identify an analysis run of a section of core.	Text 6
Run Date/Time	Timestamp when analysis was run.	Text 16 (yyyy-mm-dd hh:mi)
Core Temp (C)	Temperature of the core in ^{o}C.	Decimal F4.1
Raw Data	Y or N if raw data collected and saved.	Text 1
Measurement No.	Number of the measurement at a given interval. Used to differentiate multiple measurements at the same interval.	Integer 2
Separation	The measured separation of a pair of transducers.	Decimal F7.3
Measured Time	The average time measured for a signal to travel between transducers for a velocity measurement.	Decimal F6.3
Calib Date/Time	Timestamp identifying when calibration was run.	Text 16 (yyyy-mm-dd hh:mi)
Calib. Delay	Calculated time calibration constant, in microseconds.	Decimal F6.3

Appendix IIB. Description of data items from PWS3 query.

Column Name	Column Description and Calculation	Format
Leg	Number identifying the cruise. The ODP started numbering the scientific cruises of the *JR* at Leg 101. A leg was nominally two months duration. During the 18+ years of the ODP, there were 110 cruises on the *JR*.	Integer 3
Site	Number identifying the site. A site is the location where one or more holes were drilled while the ship was positioned over a single acoustic beacon. The *JR* visited 656 unique sites during the course of the ODP. Some sites were visited multiple times, including some sites originally visited during the Deep Sea Drilling Program for a total of 673 site visits.	Integer 4
Hole	Letter identifying the hole. Multiple holes could be drilled at a single site by pulling the drill pipe above the seafloor, moving the ship some distance away and drilling another hole. The first hole was designated 'A' and additional holes proceeded alphabetically at a given site. Location information for the cruise was determined by hole latitude and longitude. During ODP, there were 1818 holes drilled or deepened.	Text 1
Core	Cores are numbered serially from the top of the hole downward. Cored intervals are up to 9.7 m long, the maximum length of the core barrel. Recovered material was placed at the top of the cored interval, even when recovery was less than 100%. More than 220 km of core were recovered by the ODP.	Integer 3
Type	All cores are tagged by a letter code that identifies the coring method used.	Text 1
Section	Cores are cut into 1.5 m sections in order to make them easier to handle. Sections are numbered serially, with Section 1 at the top of the core. PWL measurements were made on sections. Core Catcher sections identified as "CC".	Integer 2 (Text 2)
Top (cm)	The top interval of a measurement in centimeters measured from the top of a section.	Decimal F5.1
Bottom (cm)	The bottom interval of a measurement in centimeters measured from the top of a section.	Decimal F5.1
Depth (mbsf)	Distance in meters from the seafloor to the sample location.	Decimal F7.3
Direction	Direction of measurement relative to a section of core. X - perpendicular to core axis and perpendicular to split surface, Y - perpendicular to core axis and parallel to split surface, Z - parallel to core axis.	Text 2
Velocity (m/s)	Calculated compressional velocity in meters per second.	Decimal F10.4
Run Number	Number generated by the data acquisition software, to identify an analysis run of a section of core.	Text 6
Run Date/Time	Timestamp identifying when analysis was run.	Text 16 (yyyy-mm-dd hh:mi)
Core Temp (C)	Temperature of the core in ^{o}C.	Decimal F4.1
Raw Data	Y or N if raw data collected and saved.	Text 1
Measurement No.	Number of the measurement at a given interval. Used to differentiate multiple measurements at the same interval.	Integer 2
Separation Mean (mm)	The average measured separation of a pair of transducers. Valid values 0-255. Changed to N(6,3) in August 2000 because of a change in the data acquisition code.	Decimal F6.3
Time Mean (ms)	The average time measured for a signal to travel between transducers for a velocity measurement, in microseconds.	Decimal F6.3

Column Name	Column Description and Calculation	Format
Calib Date/Time	Timestamp identifying when calibration was run.	Text 16 (yyyy-mm-dd hh:mi)
Liner Correction	Y or N if liner correction used.	Text 1
Standard	Name of a physical properties standard.	Text 20
Standard Set	The name for a set of physical properties standards.	Text 20
Standard Expected	The value of a property associated with a physical properties standard.	Decimal F13.6
Contact Pressure (kPa)	The contact pressure on the transducer when in contact with core material or liner.	Decimal F5.1
Liner thickness (mm)	Thickness of the liner in mm. If liner correction = No then this value is set to zero.	Decimal F5.3
Calib Delay M0	Calculated time calibration constant, in microseconds.	Decimal F6.3
Calib Delay M1	Calculated time calibration slope, in microseconds/millimeter. Changed name from delay_1_m1 to delay_1_over_m1, Dec. 2000.	Decimal F6.1
Calib Delay Mean Square Error	Mean square error from time calibration line.	Decimal F8.6
Calib Separation M0 (mm)	Calculated distance calibration constant in millimeters.	Decimal F7.3
Calib Separation M1 (mm/V)	Calculated distance calibration slope, in millimeters per volts	Decimal F6.4
Calib Separation Mean Square Error	Mean square error in distance calibration constant calculation	Decimal F8.6